June 7, 2019

"China's Current Capabilities, Policies, and Industrial Ecosystem in AI"

Testimony before the U.S.-China Economic and Security Review Commission
Hearing on Technology, Trade, and Military-Civil Fusion: China's Pursuit of Artificial Intelligence, New Materials, and New Energy

Jeffrey Ding
D.Phil Researcher, Center for the Governance of AI
Future of Humanity Institute, University of Oxford

Introduction[1]

This testimony assesses the current capabilities of China and the U.S. in AI, highlights key elements of China's AI policies, describes China's industrial ecosystem in AI, and concludes with a few policy recommendations.

China's AI Capabilities

China has been hyped as an AI superpower poised to overtake the U.S. in the strategic technology domain of AI.[2] Much of the research supporting this claim suffers from the "AI abstraction problem": the concept of AI, which encompasses anything from fuzzy mathematics to drone swarms, becomes so slippery that it is no longer analytically coherent or useful. Thus, comprehensively assessing a nation's capabilities in AI requires clear distinctions regarding the object of assessment.

This section compares the current AI capabilities of China and the U.S. by slicing up the fuzzy concept of "national AI capabilities" into three cross-sections: 1) scientific and technological (S&T) inputs and outputs, 2) different layers of the AI value chain (foundation, technology, and application), and 3) different subdomains of AI (e.g. computer vision, predictive intelligence, and natural language processing). *This approach reveals that China is not poised to overtake the U.S. in the technology domain of AI; rather, the U.S. maintains structural advantages in the quality of S&T inputs and outputs, the fundamental layers of the AI value chain, and key subdomains of AI.*

A. Outputs and Inputs

[1] I thank Toby Shevlane and Max Daniel for feedback on this written testimony.
[2] See, for example: Kai-Fu Lee, *AI Superpowers: China, Silicon Valley, and the New World Order,* 2018, Houghton Mifflin Harcourt.

One approach to measure national S&T capabilities divides indicators into outputs (e.g. scientific papers, patents) and inputs (e.g. R&D investment, talent).[3] Assessing both types of indicators is essential: Outputs do not reflect all the innovative potential of the inputs, and some inputs may not materialize into productive gains.

In the domain of outputs, China leads the world in the quantity of both patent filings and scientific publications related to AI, but it significantly trails the United States in the quality of those patents and papers. Followed by the U.S. patent office, the Chinese patent office accepts the most first patent filings in AI — a trend since 2014, per a report by the World Intellectual Property Organization (WIPO).[4] As for publications of AI papers, according to a scientometric analysis of Elsevier's Scopus database, China has led the U.S. in this indicator since 2006.[5] In a similar vein, the Obama Administration's strategic plan for AI research showed that the U.S. trailed China in journal articles related to "deep learning," a powerful subset of machine learning techniques.[6]

However, accounting for the quality of patents and publications reveals that China's lead in raw counts does not necessarily translate into "superpower" status in AI capabilities. The same WIPO report found that China ranks fifth, far behind the U.S. (first), in terms of highly cited patent families filed at its patent office; additionally, compared to the U.S. (32 percent) and Japan (40 percent), only 4 percent of patent applications first filed in China are then filed in other jurisdictions.[7] Moreover, one econometric analysis concluded that China's patent subsidy programs inflate patent counts by more than 20 percent.[8] As is the case with patents, taking into account the quality of papers significantly deflates China's lead in publication counts. In 2016, Chinese AI papers were fifteen percent less cited than the global average, whereas U.S. AI papers were cited 83 percent more than the world average.[9]

On the input side, the amount of R&D investment in AI is an important, but often mis-operationalized, indicator of the strength of a nation's AI ecosystem. For instance, a 2018 White Paper by a U.S. House subcommittee on information technology argued that China's rapidly

---

[3] This approach draws inspiration from Robert L. Paarlberg, Knowledge as Power: Science, Military Dominance, and US Security," *International Security*, *29*(1), pp.122-151.

[4] World Intellectual Property Organization, "WIPO Technology Trends 2019: Artificial Intelligence," 2019, https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf.

[5] Yoav Shoham et al., "The AI Index 2018 Annual Report", AI Index Steering Committee, Human-Centered AI Initiative, Stanford University, December 2018, http://cdn.aiindex.org/2018/AI%20Index%202018%20Annual%20Report.pdf.

[6] Sarah Zhang, "China's Artificial-Intelligence Boom," The Atlantic, February 16, 2017, https://www.theatlantic.com/technology/archive/2017/02/china-artificial-intelligence/516615/; original report: "The National Artificial Intelligence Research and Development Strategic Plan," National Science and Technology Council, October 2016, https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf.

[7] https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf

[8] Jianwei Dang and Kazuyuki Motohashi, "Patent statistics: A good indicator for innovation in China? Patent subsidy program impacts on patent quality," China Economic Review 35 (2015): 137-155.

[9] "The AI Index 2018 Annual Report"

growing investments in AI pose a risk to U.S. leadership in the domain.[10] Reflecting the difficulty of pinpointing AI expenditures, the only piece of evidence cited in support of this claim was China's overall R&D expenditures.[11]

More specific government R&D indicators exist but they provide an incomplete view of the landscape, especially given the prominence of corporate R&D in AI. For example, the Chinese Ministry of Industry and Information Technology plans to spend $950 million annually on strategic AI projects in the public sector and state-owned enterprises.[12] In comparison, the U.S. government invested $1.1 billion in unclassified AI-related R&D projects in 2015.[13] Corporate R&D expenditures on AI most likely dwarf these figures. Here, the U.S. lead is substantial. Out of the top 20 "Software & Computer Services" companies in 2018 R&D spending, twelve call the U.S. home, three each are based in China and Japan, and two are located in Europe.[14] Alphabet, Google's parent company, leads the pack with nearly $15 billion in R&D expenditures.

Lastly, human talent may be the most valuable input into a nation's AI ecosystem. Three major mapping projects support the conclusion that China is second only to the U.S. in the number of "AI practitioners" but is far behind in the number of "AI experts."[15] Using a broader definition of AI talent closer to the "AI practitioner" concept, Tencent Research Institute found that China boasts 39,200 AI talents (13 percent of the global total) and the U.S. has 78,700 AI talents (26 percent of the global total).[16] Defining AI talent in narrow terms, ElementAI traced only two percent of the world's AI experts to China, compared to 41 percent of the world's AI experts in America.[17] Researchers at Tsinghua University backed up both claims. Based on their methodology, China ranks second globally with an AI talent pool at around 65 percent of the U.S. talent pool (the "AI practitioner" angle) and sixth globally in terms of top AI talents (the "AI experts" angle).[18]

---

[10] Will Hurd and Robin L. Kelly, "Rise of the Machines: Artificial Intelligence and Its Growing Impact on U.S. Policy," U.S. Congress, House of Representatives, Committee on Oversight and Government Reform, https://www.hsdl.org/?abstract&did=816362.

[11] Taking R&D spending on all domains to be a proxy for R&D investment in AI may be one of the clearest examples of the AI abstraction problem in practice.

[12] "Realising the Economic and Societal Potential of Responsible AI in Europe," Accenture, Spring 2018, https://www.accenture.com/_acnmedia/PDF-74/Accenture-Realising-Economic-Societal-Potential-Responsible-Ai-Europe.pdf.

[13] "The National Artificial Intelligence Research and Development Strategic Plan."

[14] These are the total R&D budgets of companies in the "Software & Computer Services" category as defined by the EU Scoreboard 2018 dataset: http://iri.jrc.ec.europa.eu/data.html

[15] I define AI practitioners as those capable of participating in AI-related projects in corporate and university settings. Though they may not have advanced degrees, they have the ability to plug-and-play with existing AI packages and apply them to specific problem sets. AI experts, who often have advanced degrees, may boast more patents and publications to their names.

[16] Tencent Research Institute, "2017 White Paper on Global AI Talent [2017全球人工智能人才白皮书]," 2017, https://www.tisi.org/Public/Uploads/file/20171201/20171201151555_24517.pdf.

[17] Gagne et al, "Global AI Talent Report 2018," Element AI, February 7, 2018, https://jfgagne.ai/talent/.

[18] China Institute for Science and Technology Policy at Tsinghua University, "China AI Development Report 2018," Tsinghua University, July 2018, http://www.sppm.tsinghua.edu.cn/eWebEditor/UploadFile/China_AI_development_report_2018.pdf; these

B. The Foundation, Technology, and Application Levels of AI

Most assessments of AI capabilities focus on the technology and application layers, as captured by emerging startups and new products, such as smart speakers. Indeed, the growth of China's AI startup scene, backed by a more mature domestic venture market as well as international capital, has been impressive. From 2014 to 2016, the number of new Chinese AI companies constituted 55 percent of all Chinese AI companies ever established, and the scale of Chinese AI investment for those three years accounted for over 90 percent of the total Chinese financing that has ever been committed to AI.[19] Moreover, in 2017, China's AI startup scene received 48 percent of funding going to AI startups globally, surpassing U.S. AI startups, which received 38 percent of the global share.[20]

The U.S. lead is more clear at the foundational level of AI, constituted by the platform and support architecture that power key technologies and applications. This includes the open source software that underpins many AI projects. According to a Chinese government white paper on the topic, the U.S. serves as the home base for the main developers of 66 percent of the world's AI open source software (AOSS), while only 13 percent of AOSS is mainly developed in China.[21] This is a notable weakness of China's AI ecosystem as these backbone systems enable companies to source top talent, shape technical standard-setting, and attract more usage of their products.[22] It is no surprise that the contributors to the AOSS white paper, which included Peking University, Baidu, and Huawei, emphasized AOSS as "an area that must be fought for in seizing global dominance in AI."[23]

C. Different Subdomains of AI

The U.S. and China possess comparative advantages in different subdomains of AI. On the one hand, China has pushed ahead in facial recognition, publishing 900 patents in this subdomain in 2017, with many belonging to unicorn startups such as Sensetime, Megvii (Face++), and Cloudwalk.[24] That same year, less than 150 patents related to facial recognition were filed in the states.[25] In Chinese-language data processing, speech recognition, and knowledge maps,

---

researchers also found that China's AI talents are mostly concentrated at universities, constituting 81.3% of the national total.

[19] Wuzhen Institute, 2017, Global AI Development Report (Framework Document) 全球人工智能发展报告(框架篇), http://www.199it.com/archives/617596.html.

[20] CB Insights, "Top AI Trends to Watch in 2018," 2018, https://www.cbinsights.com/research/report/artificial-intelligence-trends-2018/.

[21] Ministry of Industry and Information Technology, "White Paper on China's Artificial Intelligence Open Source Software" [中国人工智能白皮书], July 2018, https://pan.baidu.com/s/1p8hAM8Ggz4LjXagO62-AYg.

[22] Gregory Allen, "Understanding China's AI Strategy," Center for New American Security, February 6, 2019, https://www.cnas.org/publications/reports/understanding-chinas-ai-strategy#fn37.

[23] "White Paper on China's Artificial Intelligence Open Source Software"

[24] CB Insights, "China's Surveillance State: AI Startups, Tech Giants Are At The Center Of The Government's Plans," March 20, 2018, https://www.cbinsights.com/research/china-surveillance-ai/.

[25] CB Insights, "AI Trends to Watch in 2019," March 19, 2019, https://www.cbinsights.com/research/ai-trends-2019/.

Chinese companies benefit from their proximity to the local user base, though Microsoft has made substantial inroads in the Chinese-language natural language processing (NLP) industry.[26]

On the other hand, the U.S. possesses a decisive advantage in many business applications of AI due to its corporate culture and more standardized data practices. Additionally, American firms have a sizeable lead in autonomous vehicles, one of the most lucrative markets for AI.[27] Finally, the U.S. innovative output in military applications of AI laps the rest of the world. Between 2003-2015, there were over 700 military patents filed in the U.S. with the terms "autonomous" or "unmanned" in the patent abstract; the comparable figure in China for that time period was less than 100.[28]

China's AI Policies[29]

The key, guiding document of China's AI strategy in both the domestic and international realm is the State Council's July 2017 AI Development Plan (AIDP).[30] The plan laid out key benchmarks for China's AI industry, sent a clear signal that AI was a national-strategic level priority, and emphasized priority areas where government action could cultivate a favorable environment for sustainable, technical advances. The plan outlines a three-stage progression toward China's ambition of leading the world in AI:

1. By 2020, China's AI industry will be "**in line"** with the most advanced countries, with a core AI industry gross output exceeding RMB 150 billion ($22.5 billion) and AI-related industry gross output exceeding RMB 1 trillion ($150.8 billion).
2. By 2025, China aims to reach a "**world-leading"** level in some AI fields, with a core AI industry gross output exceeding RMB 400 billion ($60.3 billion) and AI-related industry gross output exceeding RMB 5 trillion ($754.0 billion).

---

[26] Jia Wei, "Dialogue with MSRA Vice Dean Zhou Ming: Looking back at the past and looking forward to the future, what are the development trends of NLP?" [对话MSRA副院长周明：回望过去，展望未来，NLP有哪些发展趋势?], *jiqizhixin*, February 11, 2019, https://mp.weixin.qq.com/s/rXbuXIs58w28Z7iM55jhfA?fbclid=IwAR1gARB_dDFNOMoYhkpUIwn9cdYT-5BHubVMqA9rtluMHwTmndfwMYaGCM8.

[27] Remco Zwetsloot, Helen Toner,, and Jeffrey Ding, "Beyond the AI Arms Race: America, China, and the Dangers of Zero-Sum Thinking," Foreign Affairs, November 16, 2018, https://www.foreignaffairs.com/reviews/review-essay/2018-11-16/beyond-ai-arms-race.

[28] Jon Schmid, "The Determinants of Military Technology and Diffusion," Unpublished Ph.D. Dissertation, May 2018, https://smartech.gatech.edu/bitstream/handle/1853/59877/SCHMID-DISSERTATION-2018.pdf.

[29] This section draws heavily from my report: Jeffrey Ding, "Deciphering China's AI Dream," Future of Humanity Institute Technical Report, March 2018, https://www.fhi.ox.ac.uk/wp-content/uploads/Deciphering_Chinas_AI-Dream.pdf.

[30] State Council, "State Council Notice on the New Generation Artificial Intelligence Development Plan" [国务院关于印发新一代人工智能发展规划的通知], July 8, 2017, http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm.

3. By 2030, China seeks to become the world's "**primary"** AI innovation center, with a core AI industry gross output exceeding RMB 1 trillion ($150.8 billion) and AI-related gross output exceeding RMB 10 trillion ($1.5 trillion).

In a broad sense, these benchmarks map neatly onto three strategic phases of AI development: (1) catching up to the most advanced AI powers, (2) becoming one of the world leaders in AI, and (3) achieving primacy in AI innovation.

Apart from the benchmarks, the bulk of the AIDP text underscores three key features of China's approach to AI development.

1. **Central guidance, local implementation:** The State Council set forth a "wish list" of theoretical breakthroughs and specific AI applications, prompting many local governments to establish their own AI plans and AI funds.[31] 2018 was dubbed "The Year of Local AI Policy," as 15 of the 31 provincial-level governments in China issued AI plans in the year following the AIDP. The combined targets for the scale of the AI industry of these subnational governments nearly tripled the 2020 national-level target.[32]
2. **Focus on standards:** The AIDP demonstrated the Chinese government's desire to play an active role in the construction of international technical standards for AI.[33] In January 2018 a joint effort of more than 30 academic and industry organizations, overseen by the China Electronic Standardization Institute, produced a "White Paper on Artificial Intelligence Standardization" to coordinate the development of AI standards. These efforts are motivated by multiple aims: building reliable AI-enabled systems, promoting the global competitiveness of Chinese tech companies, and achieving the soft benefits of setting the rules of the road in a strategic technology area.[34]
3. **Investment in AI talent:** China's "whole-of-society," long-term approach toward recruiting and training AI talent is bearing some fruit. The State Council's AI plan outlines a two-pronged "gathering" and "training" approach. Under the gathering plank, national-level and local-level talent programs attract international AI talents to work in China. Following the path of other multinationals, China's tech giants have also set up their own overseas R&D institutes to recruit foreign talent.[35] On the training side, China has made

[31] Matt Sheehan, "How China's Massive AI Plan Actually Works," February 12, 2018, https://macropolo.org/analysis/how-chinas-massive-ai-plan-actually-works/.

[32] Qianzhan Chanye Research Institute, "An Article that Reviews the Latest Policies for the AI Industry throughout the Country in 2018!" [一文带你了解2018年全国各地人工智能行业最新政策!], March 30, 2018, www.qianjia.com/html/2018-03/30_288481.html.

[33] The Chinese word for standards (标准) appears 24 times in the AIDP; for context, the Chinese word for policy (政策) appears 26 times.

[34] Jeffrey Ding, Paul Triolo, and Samm Sacks. "Chinese Interests Take a Big Seat at the Ai Governance Table," New America, June 20, 2018, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/chinese-interests-take-big-seat-ai-governance-table/.

[35] Alibaba recently invested $15 billion into global R&D, including seven overseas labs, with a priority on AI; Baidu now has two research labs in Silicon Valley; and Tencent has established a lab in Seattle.

long-term investments in enhancing AI as an academic discipline.[36] The Chinese Ministry of Education has approved the creation of an "Intelligent Science and Technology" major, which more than fifty universities and colleges have adopted. Some schools, such as Nanjing University, have established their own specialized AI institutes.[37]

If past strategic technology plans are any precedent, some aspects of China's AI strategy will under-deliver. Since its establishment in 2014, China's much-touted semiconductor fund has only spent a fraction of the $150 billion allocation and failed to spur advances at the technological frontier.[38] In robotics and smart manufacturing, local government efforts have duplicated projects, wasted money, and produced a glut of low-value products.[39]

One critical question is whether China's AI ecosystem can produce big breakthroughs in fundamental AI research — the cornerstone of U.S. structural advantages in this space. With an eye toward inspiring these fundamental breakthroughs, the Chinese government tacked the Chinese Academy of Engineering's "Artificial Intelligence 2.0" proposal onto a list of fifteen other S&T megaprojects.[40] However, previous Chinese science and technology megaprojects have diverted funds from high-quality labs toward more politically-connected entities.[41]

Undeniably, the openness of the U.S. technology ecosystem — to new ideas, new people, and new debates about AI ethics — provides the bedrock for its AI advantage.[42] For instance, the Defense Advanced Research Projects Agency has made a variety of long-term bets in AI breakthroughs. Past projects, which sparked interest in driverless cars and conversation assistants, are paying off for the U.S. now. Current projects, which include efforts to design more efficient AI chips and improve the security of AI programs, will pay off in the years to come.[43]

---

[36] "State Council Notice on the New Generation Artificial Intelligence Development Plan"

[37] "The Current Status of Artificial Intelligence Education in Domestic Universities: Urgent Need to Establish a First-level Discipline and Strengthen Industry-university Integration" [国内高校人工智能教育现状：亟须建立一级学科，加强产教融合], The Paper, April 20, 2018, https://www.thepaper.cn/newsDetail_forward_2087214.

[38] "Beyond the AI Arms Race."

[39] Jost Wübbeke et al., "Made in China 2025: The Making of a High-tech Superpower and Consequences for Industrial Countries, Mercator Institute for China Studies," December 2016, https://www.merics.org/en/papers-on-china/made-china-2025.

[40] AI 2.0 was added on in February 2017. The initial fifteen megaprojects were proposed and finalized in 2016 with the release of the "13th Five-Year Plan for National Science and Technology Innovation."

[41] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon. "China's 15-year science and technology plan," Physics today 59.12 (2006): 38.

[42] Elsa Kania, "China's AI Giants Can't Say No to the Party," Foreign Policy, August 2, 2018, https://foreignpolicy.com/2018/08/02/chinas-ai-giants-cant-say-no-to-the-party/.

[43] Will Knight, "The Out-there AI Ideas Designed to Keep the US Ahead of China," MIT Technology Review, March 8, 2019, https://www.technologyreview.com/s/613089/the-out-there-ai-ideas-designed-to-keep-the-us-ahead-of-china/.

China's Industrial Ecosystem in AI

The key players in China's AI industry can be roughly divided into established technology giants, who can leverage data from their respective user bases to optimize existing algorithms, and new startups, who are pushing the leading technological edge. The Ministry of Science and Technology (MoST) chose a mix of these giants and startups to lead the development of national AI open innovation platforms as part of a "national team" [国家队]. The team's members include: Baidu (autonomous driving), Alibaba (smart cities), Tencent (medical imaging), iFlytek (intelligent voice), and Sensetime (intelligent vision).[44]

The "national team" model differs from the traditional "national champion" approach. For one, all five are hybrid firms, backed by significant foreign capital and largely independent from government subsidies, that had already established themselves in their respective fields before being recruited to the national team.[45] Second, team members actively intrude on each other's turf, as evidenced by the fierce competition over the smart city market. Baidu, Alibaba, Tencent, and other end customers are actively working to develop their own speech and facial recognition capabilities so as to reduce reliance on the services of companies like iFlytek and Sensetime.[46]

China's industrial ecosystem in AI is connected to the global economy, and Chinese technology firms are expanding their AI footprint abroad. One notable case was a March 2018 deal between CloudWalk Technology Co., a facial recognition startup based in Guangzhou, and the Zimbabwe government. Framed by *The Global Times*, an influential Chinese tabloid, as "marking the entry of China's AI technology into Africa," the CloudWalk-Zimbabwe deal raised questions about China's export of its surveillance technology and model.[47]

As China's industrial ecosystem in AI expands internationally, Chinese planners are concerned about dependencies in key technologies. In a November 2018 speech before many of China's leadership at the 13th National People's Congress Standing Committee, Dr. Tan Tieniu, Deputy Secretary-General of the Chinese Academy of Sciences, highlighted the devastating effect of U.S. sanctions on ZTE as a warning about China's dependencies on the U.S. in core technologies. "In order to avoid repeating this disaster, China should learn its lesson about

[44] MoST designated the first batch of four in November 2017. Sensetime was selected as the fifth member in September 2018.
[45] The possible exception is iFlytek. The company's largest shareholder is China Mobile, and it was incubated under the University of Science and Technology. Also, government subsidies comprise 20-25 percent of its annual net income. I thank David Cunio of Three Body Capital for this point.
[46] One example of this is Ant Financial bringing its facial recognition software in-house, It had previously relied on technology from facial recognition startup Megvii (Face++).
[47] Global Times, "Chinese Facial ID Tech to Land in Africa," May 17, 2018, http://www.globaltimes.cn/content/1102797.shtml.

importing core electronic components, high-end general-purpose chips, and foundational software," Tan stated.[48]

Policy Recommendations

Given the U.S. structural advantages and current lead in AI, maintaining the status quo is a defensible policy option to enhance U.S. competitiveness in AI. Techno-industrial policy is a difficult endeavor, and there is a risk that even the most agreeable policy interventions — say, investing in S&T education — can backfire. For example, Michael Teitelbaum argues that in the past when the U.S. expanded its supply of scientists and engineers, the resulting boom in S&T talent quickly turned into a bust, leaving many without career prospects and deterring younger scientists from entering the field.[49] Notwithstanding this point, the following policy recommendations could help protect U.S. interests in AI:

- **Revive the Office of Technology Assessment (OTA).** Any type of AI policy — increases in R&D investments, protections against vulnerabilities and dependencies in the supply chain, reforms to the high-skilled immigration process — will require balanced assessments of where the U.S. and its rivals stand with respect to different layers and subdomains of AI. From 1972 to 1995, the OTA equipped U.S. lawmakers with crucial advice and information on topics such as the effect of globalization on the defense industrial base and the technological capabilities of the Soviet Union and Japan. Fortunately, some momentum for this proposal exists: in April 2019 U.S. House Representatives Sean Casten and Mark Takano appealed to the House Legislative Branch Appropriations Subcommittee to revive the OTA, and both right and left-leaning think tanks have supported the proposal.[50]
- **Build Bridges across the "Valley of Death" in the AI domain.** Much of current U.S. policy is focused on scrutinizing how Chinese firms and government-aligned entities are exploiting the "Valley of Death" — the immense challenge of turning a startup idea or scientific research into large-scale commercial applications — by investing in promising AI companies.[51] Rather than relying solely on a reactive strategy, the U.S. government should proactively build bridges across the Valley of Death. One such bridge is a Department of Defense loan program office (modeled after the one in the Department of

[48] English translation of Tan Tieniu's speech is available via Cameron Hickert and Jeffrey Ding (translators), "Read What Top Chinese Officials Are Hearing About AI Competition and Policy" New America, November 29, 2018, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/read-what-top-chinese-officials-are-hearing-about-ai-competition-and-policy/.

[49] Michael S. Teitelbaum, "Falling Behind? Boom, Bust, and the Global Race for Scientific Talent," Princeton University Press, https://press.princeton.edu/titles/10208.html.

[50] Katherine Tully-McManus, "House Members Call for Office of Technology Assessment Revival," Roll Call, April 2, 2019, https://www.rollcall.com/news/congress/house-members-call-office-technology-assessment-revival.

[51] The case of Neurala is instructive. This smart drone startup was unable to attract investment from the U.S. military so it turned toward an investment firm backed by a state-run Chinese company instead. See: Paul Mozur and Jane Perlez, "China Bets on Sensitive U.S. Start-Ups, Worrying the Pentagon," March 22, 2017, https://www.nytimes.com/2017/03/22/technology/china-defense-start-ups.html.

Energy)[52] to coordinate with accelerators to fund high-risk, high-reward startups. Another is built on public-private consortiums to share translational research (e.g. brain collection and data analysis capabilities) across industrial partners, universities, and hospitals to improve the drug discovery process for brain disorders.[53]

- **Increase attention to the risks of accidents and emergent effects associated with the deployment of emerging technologies related to AI.[54]** Maintaining U.S. supremacy in AI over rivals such as China should not be the only policy goal; the U.S. should also guard against the risk of losing control over AI technologies. As the software components of cybersecurity and weapons systems become more complex and develop faster than existing mechanisms of control, the risks of accidents and latent vulnerabilities become greater. U.S. agencies should make these concerns a core part of quadrennial reviews, war games, and periodic intelligence and net assessments.

[52] Joshua Israel, “Commercial Accelerators and the Defense Department: A Blueprint for Collaboration, War on the Rocks, March 14, 2018, https://warontherocks.com/2018/03/commercial-accelerators-and-the-defense-department-a-blueprint-for-collaboration/.

[53] Nao J. Gamo, et al. "Valley of Death: a Proposal to Build a “Translational Bridge” for the Next Generation." Neuroscience research, 115 (2017): 1-4, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5477974/.

[54] This is drawn from Richard Danzig, “Technology Roulette: Managing Loss of Control as Many Militaries Pursue Technological Superiority,” Center for a New America Security, June 2018, https://s3.amazonaws.com/files.cnas.org/documents/CNASReport-Technology-Roulette-DoSproof2v2.pdf?mtime=20180628072101.